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(54) PROCESS FOR THE PRODUCTION OF A FOAMED OR EXPANDABLE
THERMOPLASTIC POLYMER

(71) We, BP CHEMICALS LIMITED, of Britannic House, Moor Lane, London, E.C.2, a British company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a process for the production of a foamed or expandable thermoplastic polymer. It further relates to the expandable polymer compositions so produced and to the foamed polymer produced therefrom.

Foamed and expandable thermoplastic polymers are commonly produced by an extrusion process. Thermoplastic polymer containing a blowing agent may be fed to an extruder or a volatile liquid or gaseous blowing agent directly injected into the molten polymer in the extruder barrel. The extruded polymer may either be chopped into pellets containing blowing agent which are rapidly cooled to prevent expansion, or allowed to expand through a suitable die to form, for example, foamed sheet. Pellets containing blowing agent incorporated as above or by any conventional method are known as expandable polymers and may themselves be extruded, normally but not necessarily without further injection of blowing agent, and allowed to expand out of a suitable die, or they may be expanded in a mould to give shaped foamed polymer products.

To obtain a more uniform and a smaller cell size in the foamed polymer, thus improving the mechanical properties of the foam, a nucleating agent may be incorporated in the polymer before it is foamed.

U.K. Patent Specification 783,034 described the admixture of a nucleating agent comprising an organic acid or acid salt or boric acid and a carbon dioxide liberating agent with expandable pellets containing a volatile liquid blowing agent, which are then extruded. Citric acid and sodium bicarbonate are a preferred system.

U.K. Patent Specification 1,104,165 shows a variation of this system comprising anhy-

drous citric acid, hydrated citric acid and a carbon dioxide releasing salt, for use with a direct injection process.

These systems have a number of disadvantages in practice. It is difficult to obtain a homogeneous mixture of the finely divided nucleating agent with the polymer particles to be extruded which typically have dimensions of the order of $\frac{1}{8}$ ". In addition the constituents of the nucleating system tend to absorb water, citric acid being particularly bad in this respect. Excess quantities of water are detrimental to foam quality and also increase the amount of premature reaction between the acid and the carbon dioxide releasing salt. The nucleant also has a tendency to stick to the extruder screw, which causes blocking of the feed section of the extruder.

It is an object of the present invention to provide an improved process for the production of a foamed or expandable thermoplastic polymer.

Accordingly the present invention is a process for the production of a foamed or expandable thermoplastic polymer which process comprises extruding a foamable thermoplastic polymer mixed with a salt capable of reacting with an organic acid to liberate carbon dioxide and injecting the organic acid in liquid form into the mixture of the thermoplastic polymer with the salt in the extruder and producing a foamed or expandable product.

It is possible to produce foams from a large number of thermoplastic polymers e.g. polyvinyl chloride or polyethylene but the preferred foamable thermoplastic for the process of the present invention is polystyrene, particularly general purpose polystyrene.

Any salt capable of reacting with the organic acid to liberate carbon dioxide under the extrusion conditions employed may be used. Typical examples are the carbonates and bicarbonates of alkali and alkaline earth metals. Sodium bicarbonate and particularly sodium carbonate are the preferred

[Price 25p]

salts. The amount of the salt used is suitably in the range 0.3 phr to 2.0 phr and preferably in the range 0.5 phr to 1.0 phr (all parts by weight of polymer). The salt is preferably in finely divided form and is mixed with the polymer, which will usually be in the form of extrudable pellet, in conventional dry blending apparatus.

The process of the present invention is applicable to any of the methods of producing foamed polymer or expandable polymer compositions described above. Conventional conditions of extrusion are suitable.

The organic acid must be in liquid form when it is injected, i.e. it must either be a liquid per se when it is injected or must be dissolved in a suitable liquid, for example a volatile liquid blowing agent. If it is not wished to inject a volatile liquid blowing agent into the mixture in the extruder an organic acid which is liquid under the prevailing conditions may be injected. If it is desired to inject a volatile liquid blowing agent either an organic acid in liquid form may be injected separately into the mixture in the extruder or a solid organic acid soluble in or a liquid organic acid miscible with the blowing agent may be mixed with the blowing agent and injected with it.

To obtain a uniform distribution of cells throughout the polymer it is desirable to inject the organic acid continuously at a controlled feed rate.

The preferred organic acids are organic carboxylic acids. Suitable normally liquid acids which may be directly injected into the mixture in the extruder are formic acid, acetic acid or propionic acid. As the quantities of acid needed are small this is difficult if a liquid organic acid is injected directly. Accordingly it is preferred to use an organic acid dissolved in a liquid, e.g. a volatile liquid blowing agent. Any organic acid soluble in or miscible with the chosen volatile liquid blowing agent may be injected dissolved in the blowing agent. Particularly suitable for use when pentane is employed as a blowing agent are acetic acid and oleic acid.

The amount of acid injected is suitably sufficient to give a concentration in the extruding mixture in the range 0.1 phr to 2.0 phr preferably 0.3 phr to 0.6 phr (by weight). Thus the process of the present invention is particularly suitable for a process where it is desired to directly inject a volatile liquid blowing agent and especially for the production of foamed thermoplastic sheet using direct injection of a volatile liquid blowing agent.

Many volatile liquid blowing agents are known and may be used. Examples of volatile liquid blowing agents are the volatile liquid hydrocarbons such as butane, pentane or hexane or halogenated hydrocarbons such

as methyl chloride or the volatile liquid "Freons" (Registered Trade Mark).

The preferred blowing agent for use with polystyrene is pentane, alone or in conjunction with methyl chloride.

The invention is illustrated by the following examples:—

EXAMPLE 1

0.6 parts per hundred by weight sodium carbonate were mixed with polystyrene and the mixture pelleted and the pellets extruded through a conventional tandem extruder direct injection foam sheet line. Acetic acid was dissolved in pentane (60 ml per litre pentane) and pumped at a rate sufficient to result in a concentration of 0.5 parts by weight of acetic acid per hundred parts of polymer in the extruder melt.

Good quality foam was obtained of density about 5 lbs/cu.ft. (80 Kg/m³) and with cell diameters of 0.006 to 0.010 inch (0.16 to 0.25 mm.).

EXAMPLE 2

Example 1 was repeated using polystyrene pellets dusted with 1.0 parts per hundred sodium bicarbonate, other conditions being similar.

Foam of similar density and cell diameter was produced.

WHAT WE CLAIM IS:—

1. A process for the production of a foamed or expandable thermoplastic polymer which process comprises extruding a foamable thermoplastic polymer mixed with a salt capable of reacting with an organic acid to liberate carbon dioxide and injecting the organic acid in liquid form into the mixture of the foamable thermoplastic polymer with the salt in the extruder and producing a foamed or expandable product.

2. A process according to claim 1 wherein the foamable thermoplastic polymer is polystyrene.

3. A process according to claim 1 or claim 2 wherein the salt is sodium carbonate or sodium bicarbonate.

4. A process according to any of the preceding claims wherein the amount of salt used is in the range 0.5 phr to 1.0 phr (by weight of polymer).

5. A process according to any of the preceding claims wherein the organic acid is formic acid, acetic acid or propionic acid and it is injected in undiluted form into the mixture in the extruder.

6. A process according to any of claims 1 to 4 wherein the organic acid is dissolved in a volatile blowing agent.

7. A process according to claim 6 wherein the blowing agent is pentane.

8. A process according to any of the

claim 6 or claim 7 wherein the organic acid is, acetic acid or oleic acid.

9. A process according to any of the preceding claims wherein the amount of acid injected is sufficient to give a concentration in the extruding mixture in the range 0.3 phr to 0.6 phr (by weight).

10. A process for the production of a foamed or expandable thermoplastic polymer

as described herein with reference to either 10 of the examples.

11. Foamed or expandable thermoplastics whenever produced by a process according to any of the preceding claims.

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